AFCRL-65-477

AD619496

OPTICAL PERFORMANCE

of

MULTI-CHANNEL UV and VISIBLE SPECTROGRAPH

by

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CONTRACT NO. AF19(628)-4305

Project No. 6327

FINAL REPORT

27 May 1965

Period Covered 1 April 1965 to 30 June 1965

Prepared for

Air Force Cambridge Research Laboratories
Office of Aerospace Research
United States Air Force
Bedford, Massachusetts

This research was supported by the Advanced Research Projects Agency under ARPA Order 254

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INTRODUCTION

The spectrograph under test is an Ebert Mount Spectograph designed and built by ITT Research Institute, Technology Center, Chicago, Illinois.

The sources used in testing this spectrograph were Helium and Neon Geisler tubes, powered by a 3,000-Volt transformer, a low pressure mercury tube with a quartz wall and a Mazda tungsten filament lamp. The Mercury sources were powered by a 110-Volt A.C. power source, and the Mazda lamp by a 6-Volt transformer.

Throughout the tests a 103 Fa emulsion on 35mm. film was used. This emulsion was chosen because it is highly sensitive in the visible range and reasonably sensitive in the longer wavelength range of the UV.

A standard development procedure was followed in all tests. The film was developed in D-19 at 20° C for five minutes and fixed for ten minutes.

SPECTRAL RANGE

A Hg lamp source registered the Hg line 2536 A at the lower end of the spectrogram. A Neon Geisler tube registered the line 6382 A at the upper end of the spectrogram. An extrapolation showed that the spectrogram would record lines in the wavelength range from 2500 A to 6500 A.

PLATE FACTOR

A number of line pairs in the Mercury and Neon spectrum were identified and the distance between these measured. The average plate factor was determined to be 111 Å/mm.

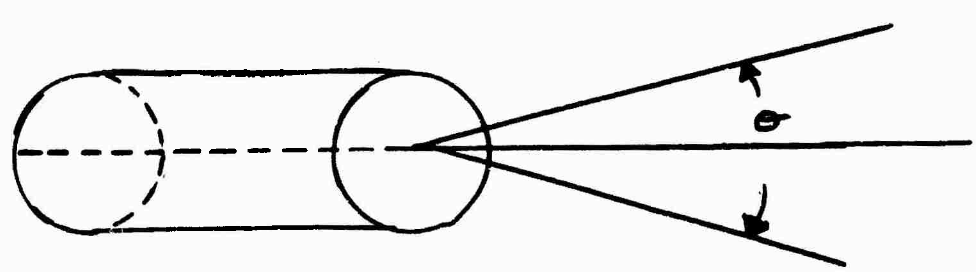
RESOLVING POWER

By controlling the exposure time of the Hg source it was possible to identify the Hg lines 3023.5Å and 3021.5Å. These lines were clearly resolved, verifying the resolving power as 2Å.

FIELDS OF VIEW

The field of view was determined by mounting a He tube on a goniometer and setting the tube at a series of angles with reference to the optical axis of the fibers. No optics were used between the He tube and the fiber ends. The Helium tube has a very narrow bore thus providing a source width of approximately a millimeter. The exposure time was standardized at 20 seconds for those tests.

The field of view is defined by the angle θ subtended at the fiber axis by the source.



Two lines in the Helium source were selected for study 5875Å and 3888Å. The density of these lines at successive angle positions of the source were measured. The relative intensities corresponding to these densities were determined from the characteristic curves and plotted against the angles on semilog paper. The lack of symmetry in these curves can be ascribed to the fact that it is extremely difficult to align the fiber axis on a fixed position. The field of view of the instrument could have been determined without the fibers but this would not be representative of the instrument as designed for flight operation. The data indicates a field of view with relatively high intensity for about 6^{o} with a lower response out to 12^{o}. The data is plotted in figures I through IV.

SPEED

The speed of a spectrograph is dependent on many factors. In addition the term is not well defined.

The most reliable source for testing the spectrograph would be a black body operating at a temperature of 3100K or 2900K. Since such a source was not available at this laboratory an automobile headlamp bulb with a tightly coiled tungsten filament and an input of 16 watts at 6 volts was used. The diameter of the filament was 0.48mm. and its length 5mm. In terms of the conventional definition of brightness the energy output is 6.66 watts/mm^2.

This source within a reasonable error is presumed to be a black body radiator. An exposure of one second was taken with the Mazda lamps

located at a distance of 40 and 30 cm respectively. The film was developed under the standard conditions given above. A microphotometer trace was taken of the transmission T vs wavelength, for the exposures. The transmission values were converted to densities, $D = \log \frac{100.}{\%T}$ The results are plotted in figures V and VI.

The characteristic curves of this emulsion were obtained by exposing the 103 Fa emulsion to the radiation from a D. C. arc operating at 5 amps and using 3/8 in. iron electrodes. The ITT spectrograph does not have sufficient dispersion to record the lines of the iron arc. This exposure was made on a Jarrell Ash 1.5 meter Wardsworth mount spectograph. The DC arc radiation was attenuated at the slit by a rotating sector with seven steps in the ratio of 1.585 to 1. The exposure time was of the order of 5 seconds so as to produce a reasonable level of densities.

By the usual two-step method the data was reduced to provide a series of curves relating the optical density to the log of the intensity I. This relation is a function of the emulsion and not of the spectrograph. The intensities given on these curves are relative.

Included in this report is a graph of the black body radiation for a source at 2900°K taken from the Tables of Black Body Radiation Functions by Mark Pivovorsky and Max R. Nagel. The ordinate is given in watts per cm^3 per steradian.

A fiber bundle consists of four fibers of 0.01 in=0.254mm. The intensity per steradian picked up by a single fiber would depend on the position of the source. The solid angle could then be calculated. Since the exposure $E = \int Idt$ the total energy recorded would then be calculated. This calculation where, I = intensity and t = time, would be reliable in the case of a single line recorded on the spectrogram. If a continuum is recorded, a correction must be made for slit width. The procedure may be found by referring to Chapter Six of PRACTICAL SPECTROSCOPY by Harrison Lord and Loofbourow, or some other standard reference book.

The abscissa is in milimicrons. Thus by choosing a band width the intensity in watts per cm^2 per steradian may be determined for any desired wavelength in the spectrum. The density that corresponds to this wavelength may be determined from the density vs wavelength curve. Then the relative intensity on the characteristic curve may be converted to an absolute value.

There is a source of error always present in this instrument, namely, the alignment of the fiber ends to the source. This is unavoidable since the instrument was designed to bend the fibers and direct them towards several sources simultaneously. However, the relatively wide field of view allows for the recording at a spectrum of a source when the fiber terminal is pointed in the direction of the source.

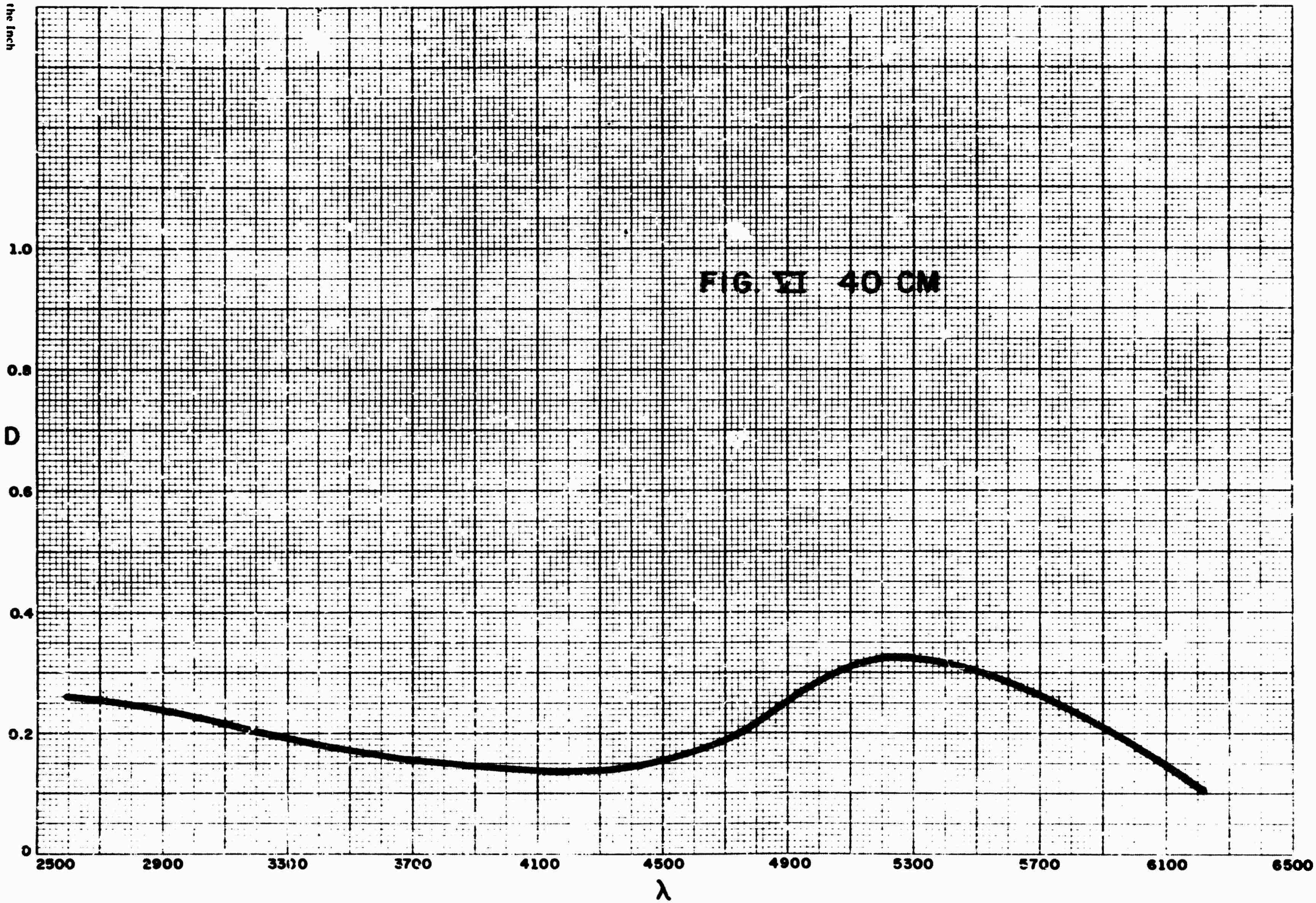
FIBERS

Several exposures were run off with each fiber bent at various angles within the limit of safety of the fibers. A Helium Geisler tube was used for these tests. The spectra compared favorably with those used to determine the angle of view.

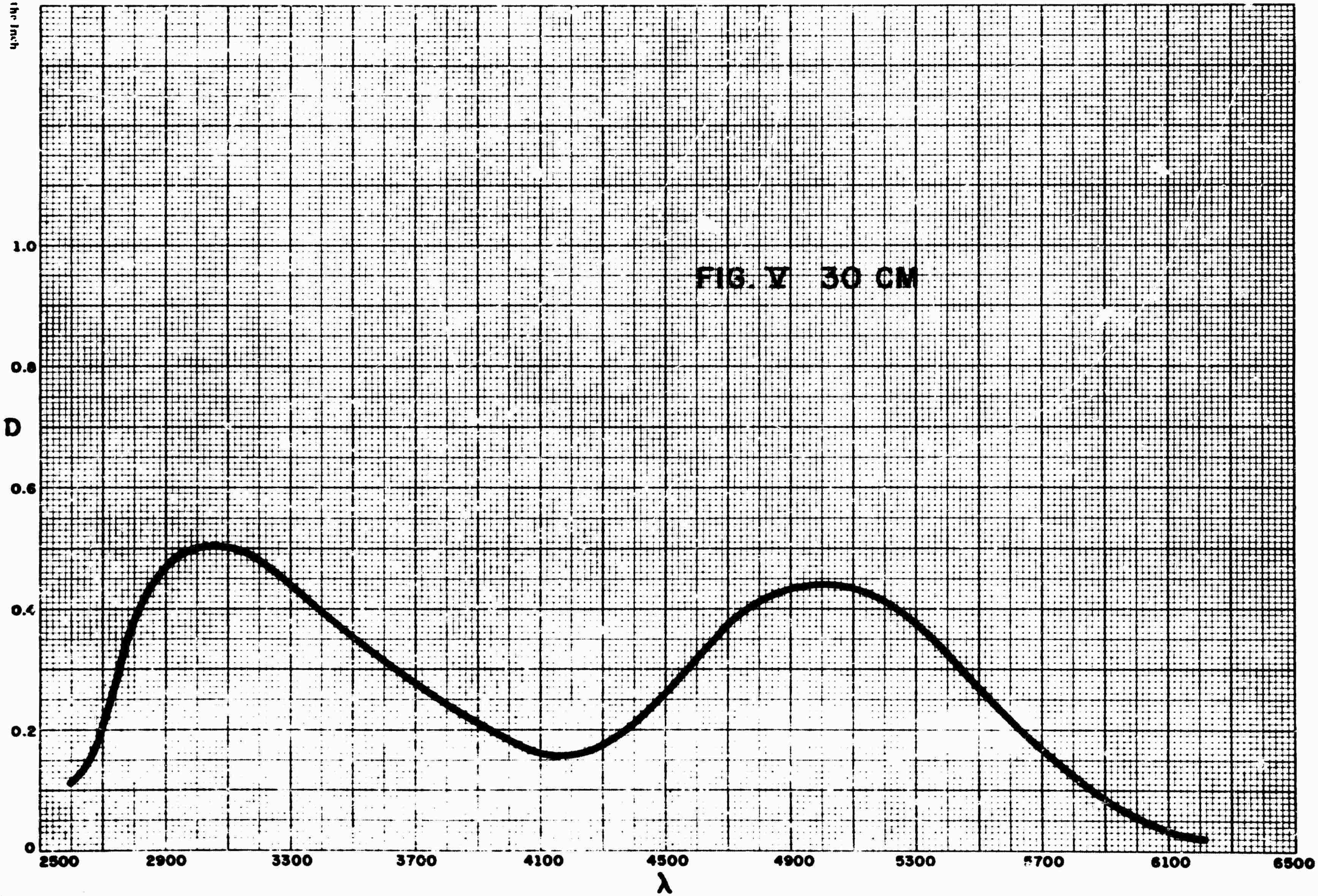
RECOMMENDATIONS

No mechanical tests were run to determine the ruggedness of the instrument. However, the open reels should be replaced by light proof magazines.

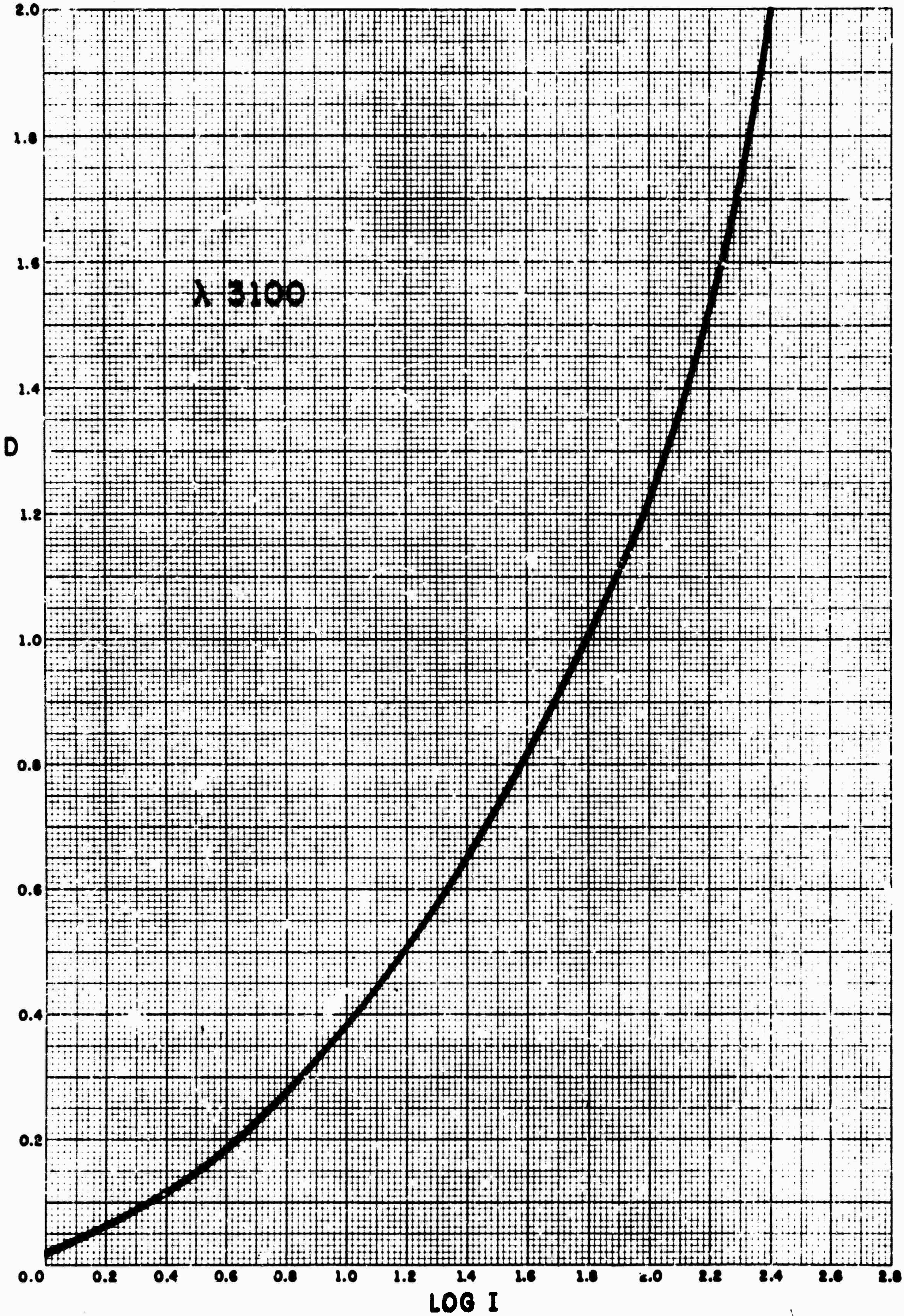
Whenever this spectrograph is used one fiber should be directed toward a quartz tube mercury lamp of moderate brightness in order to record a calibration spectrum for wavelength determinations.



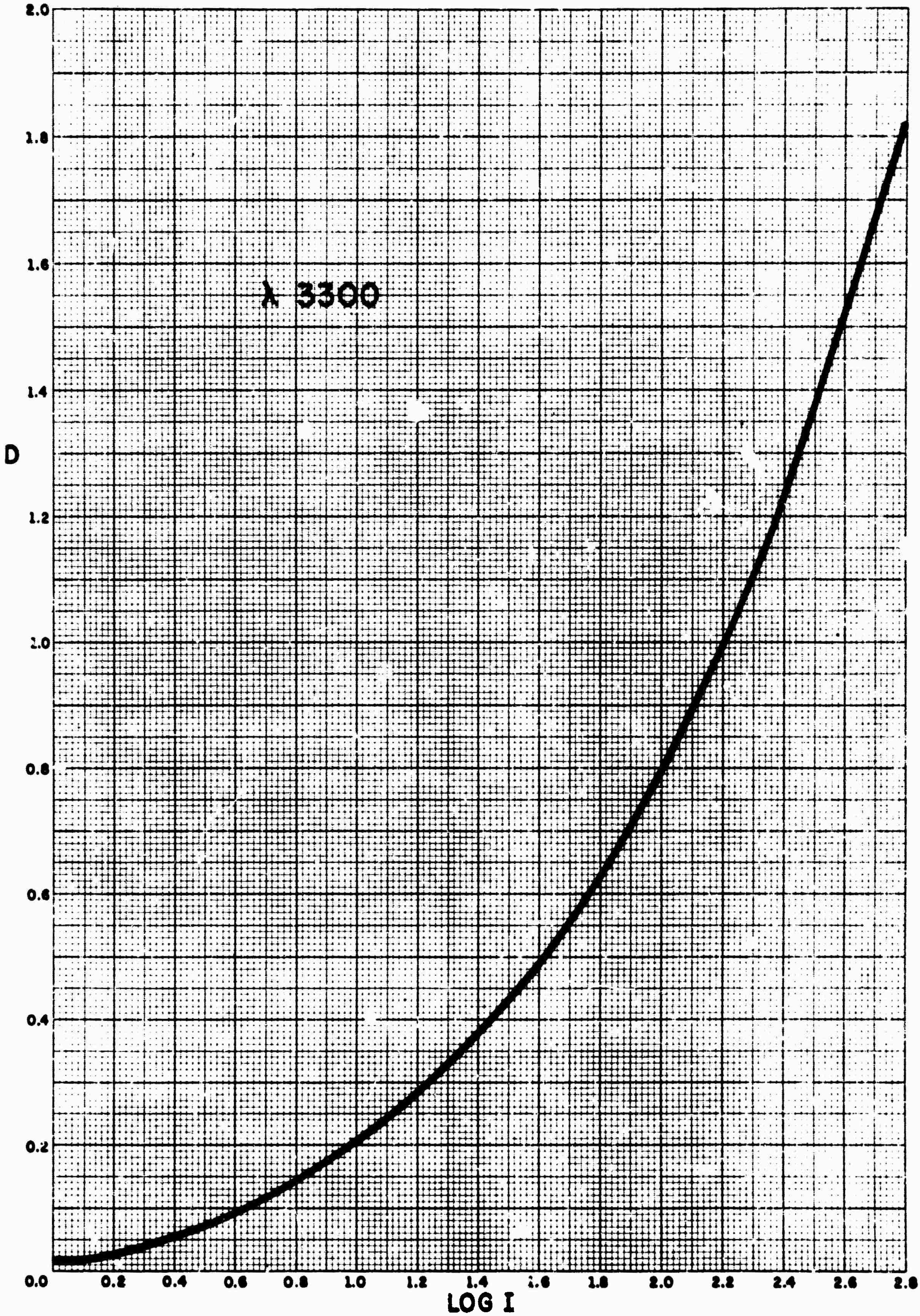
30 Squares to the Inch

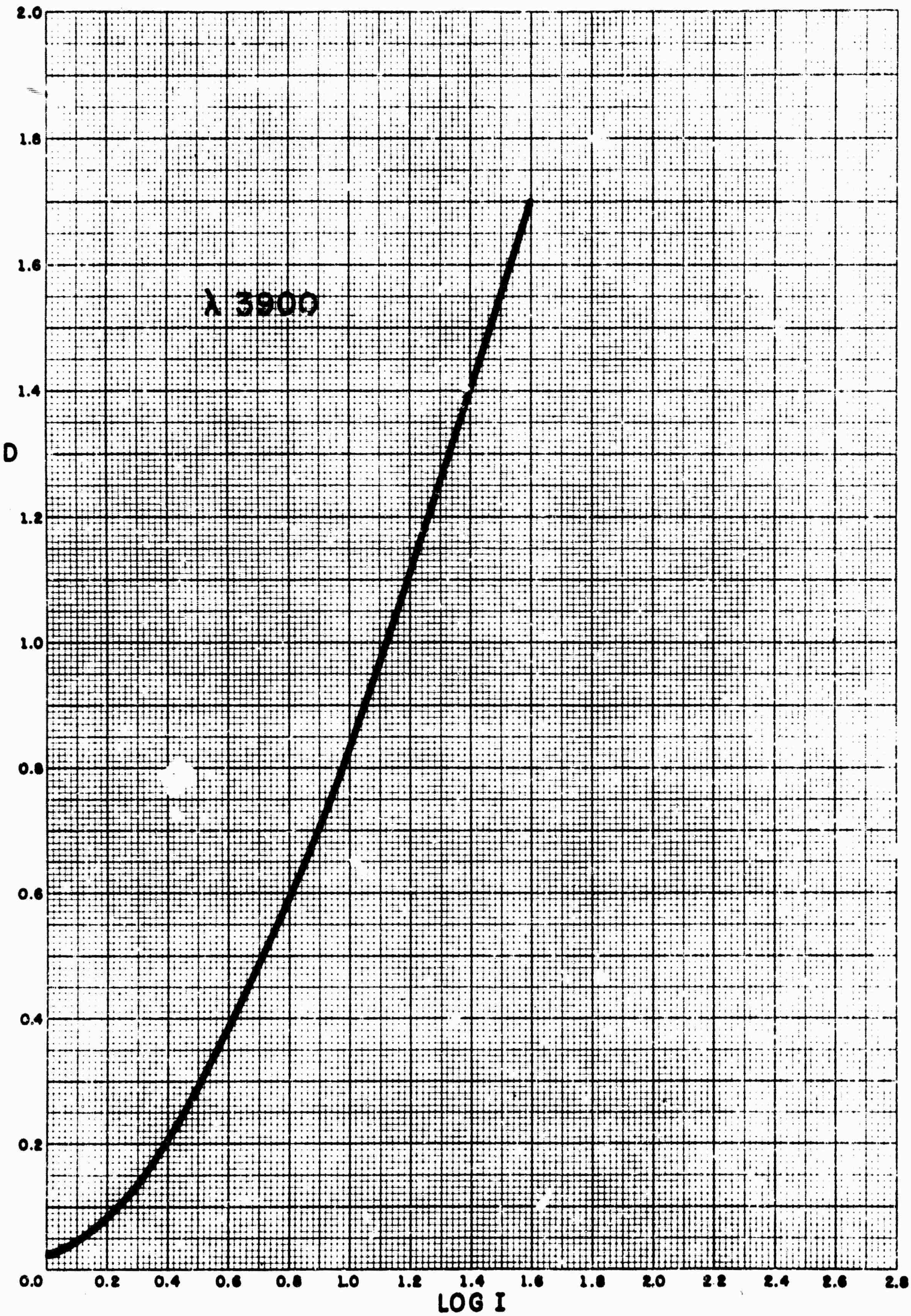


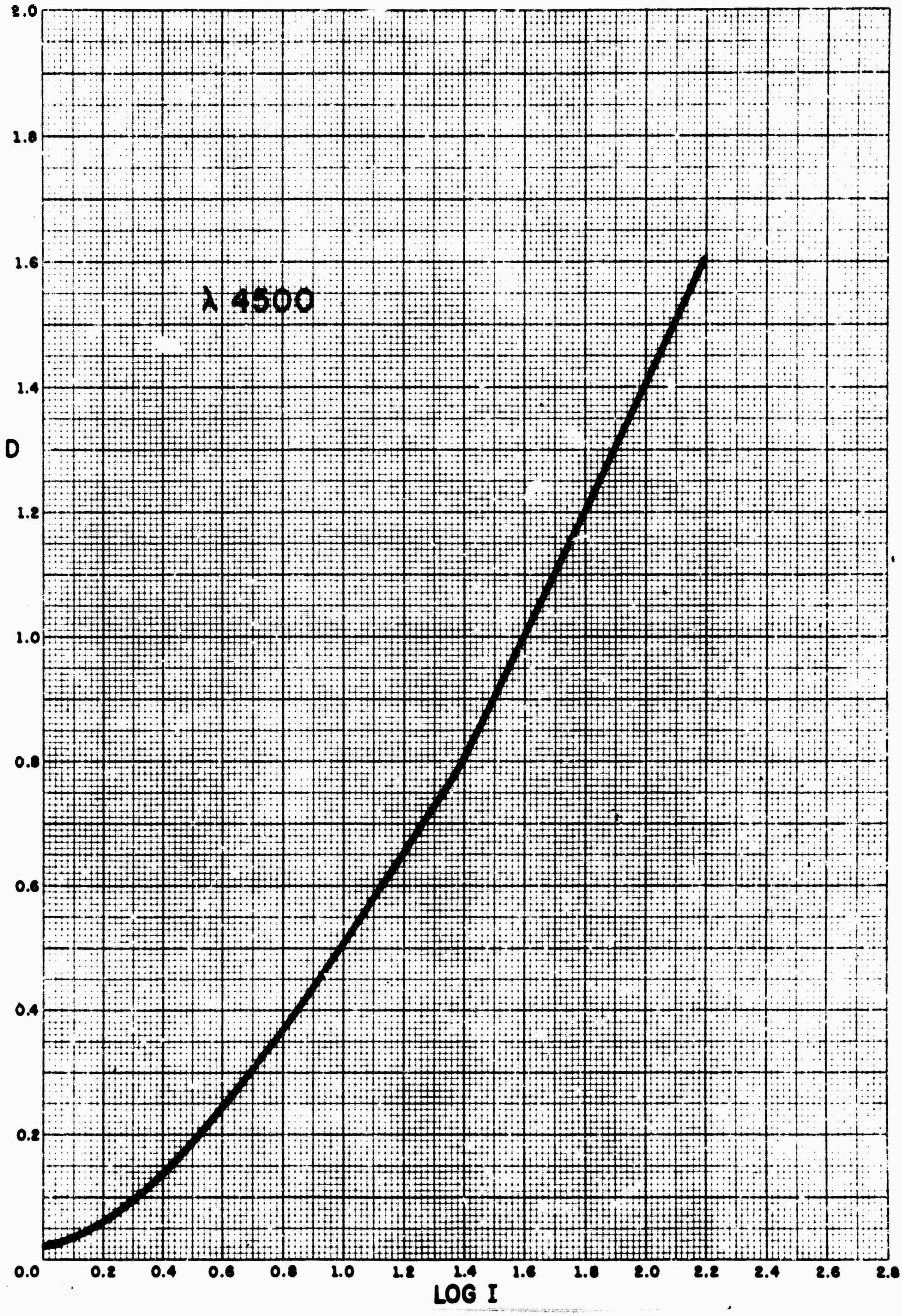
res to the Inch

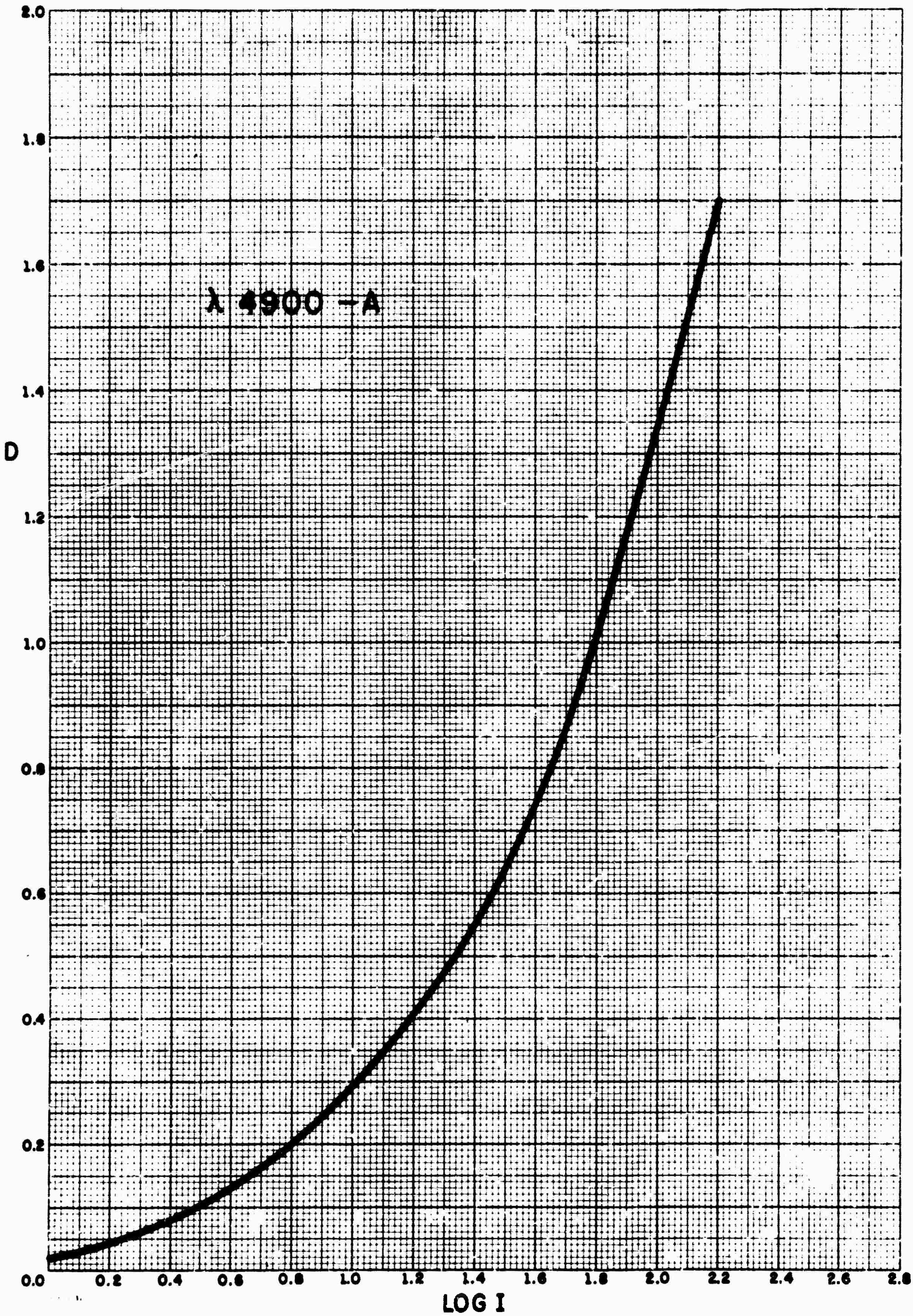


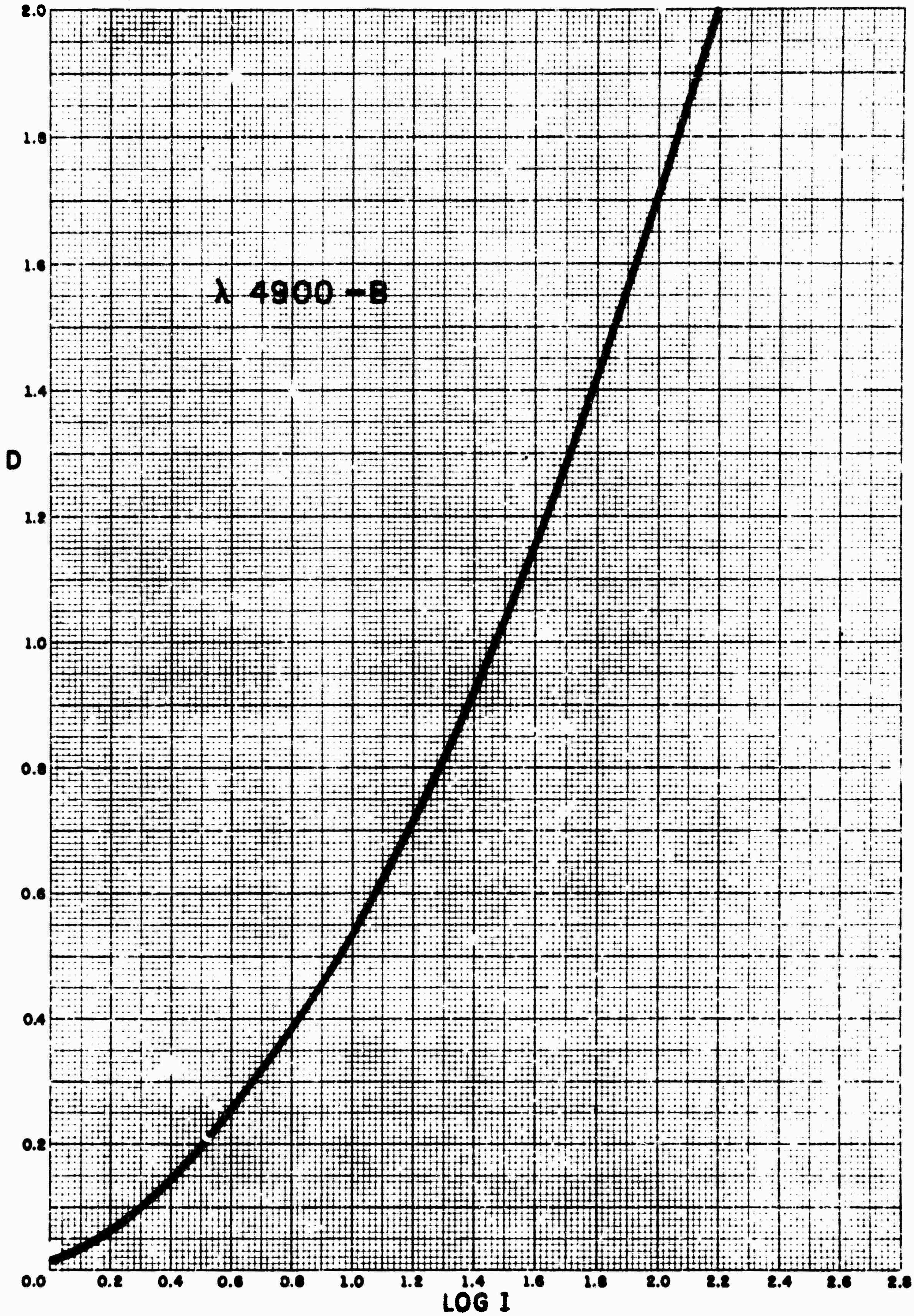
λ 3100
D
LOG I
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
D

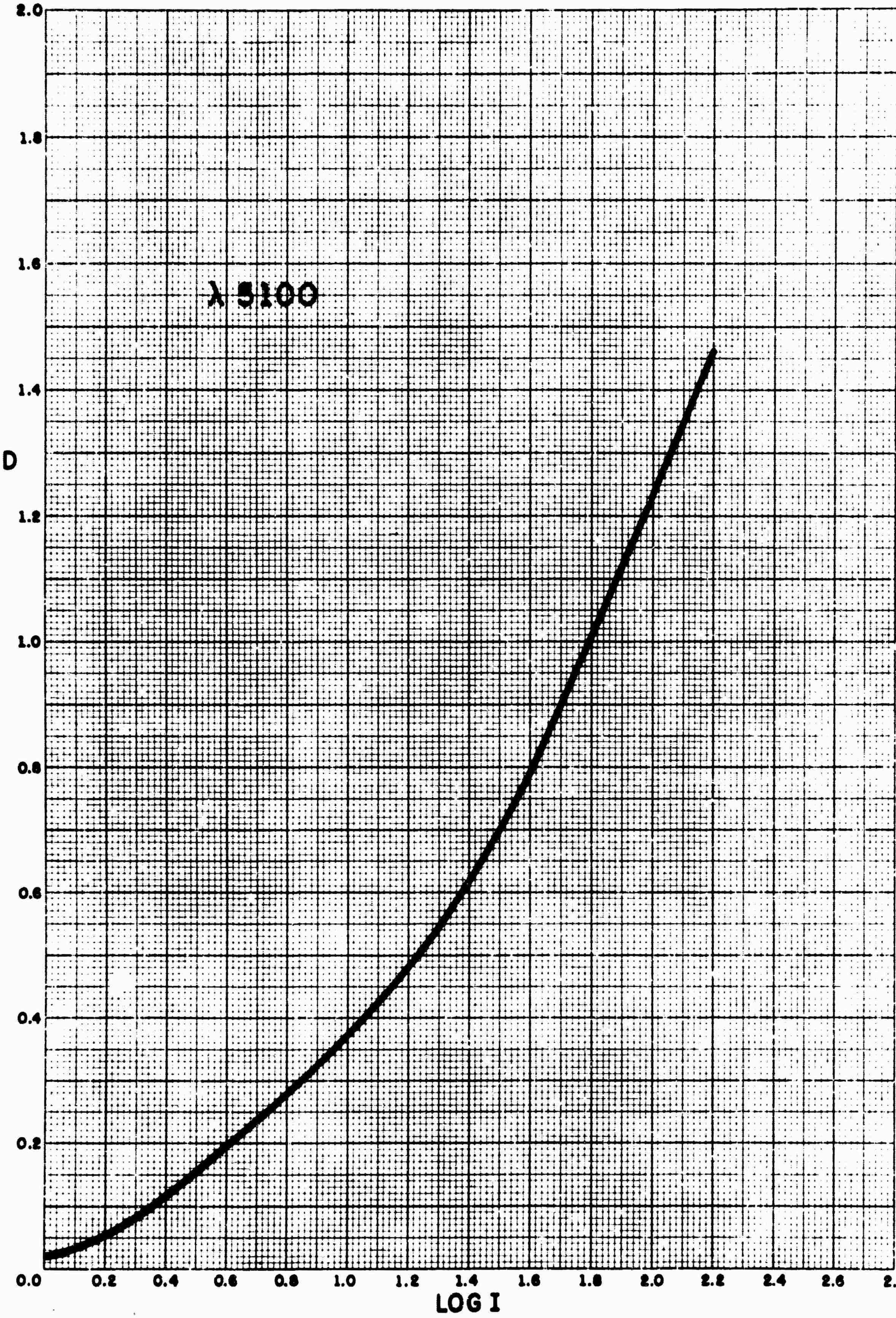

λ 3300
D
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
LOG I

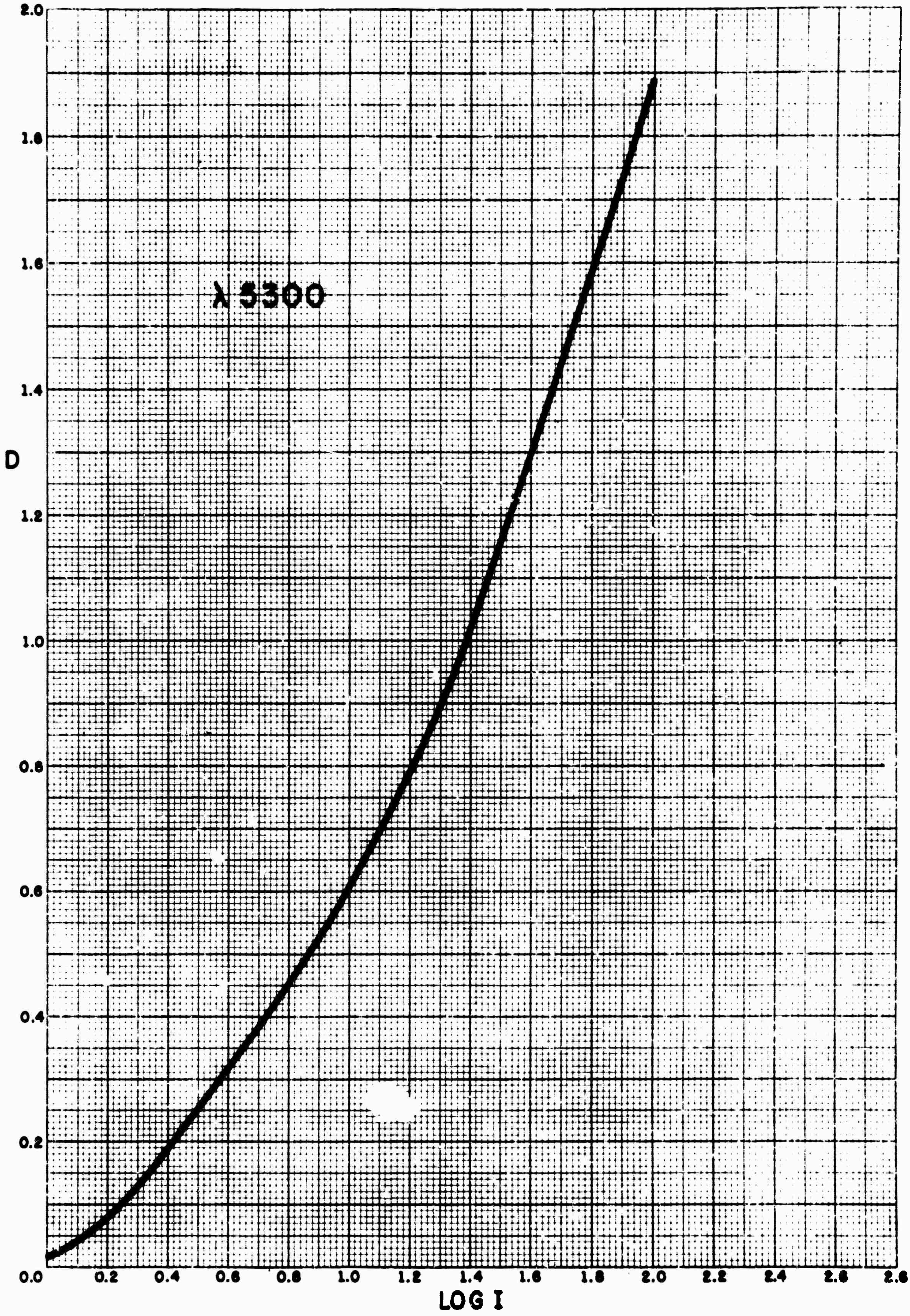

λ 3900
D
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
LOG I

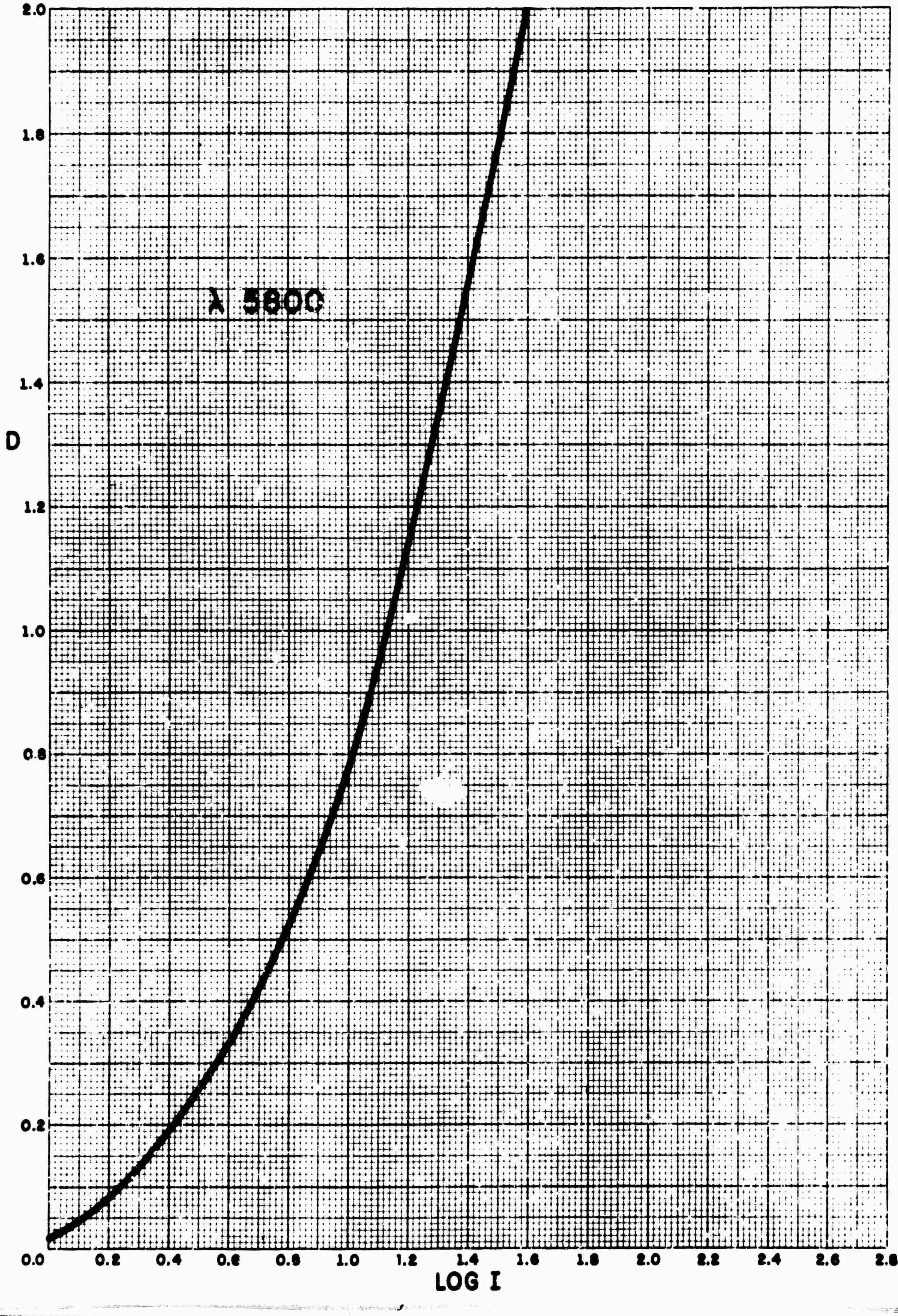

λ 4500
D
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
LOG I

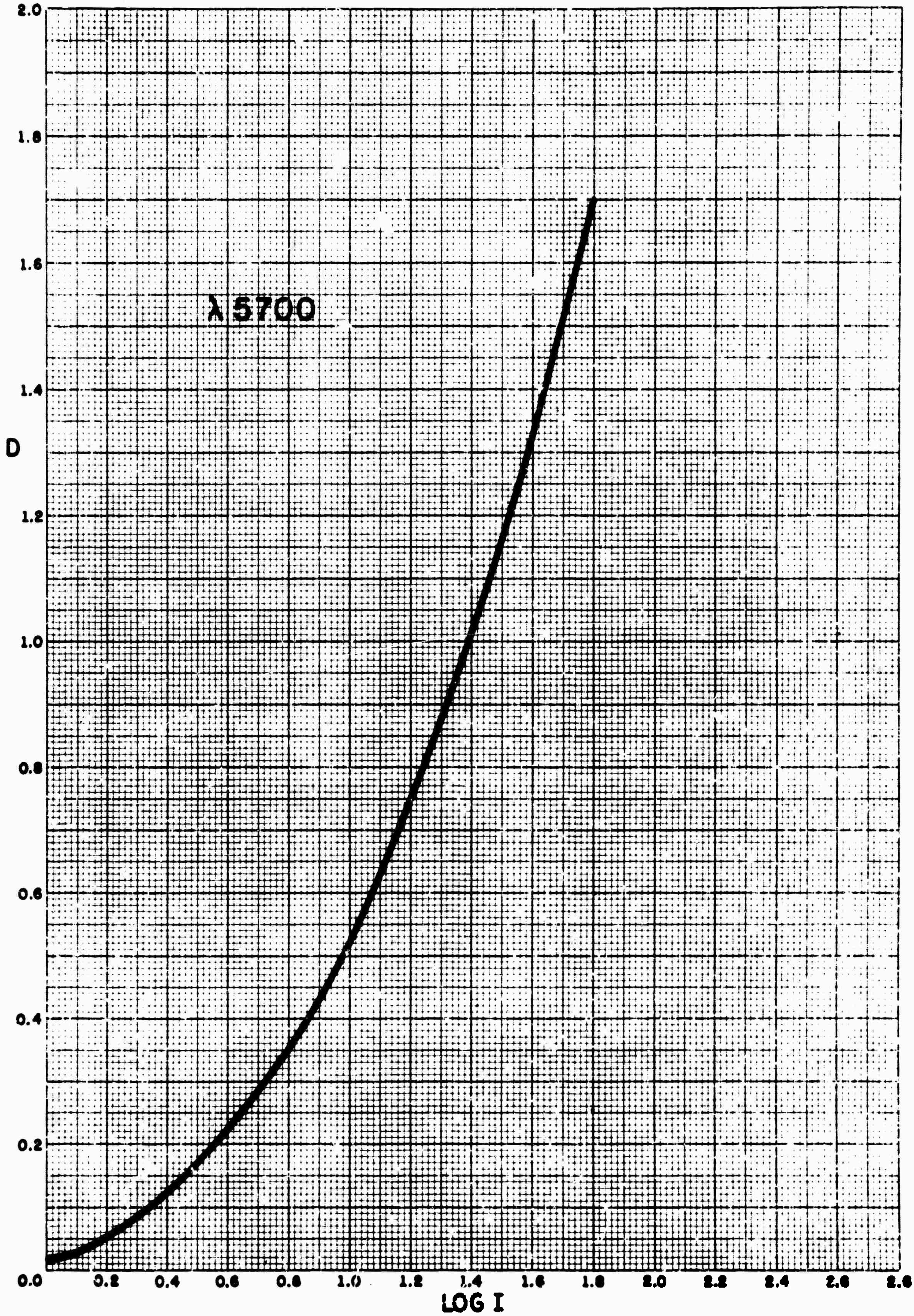

λ 4900 -A
D
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
LOG I

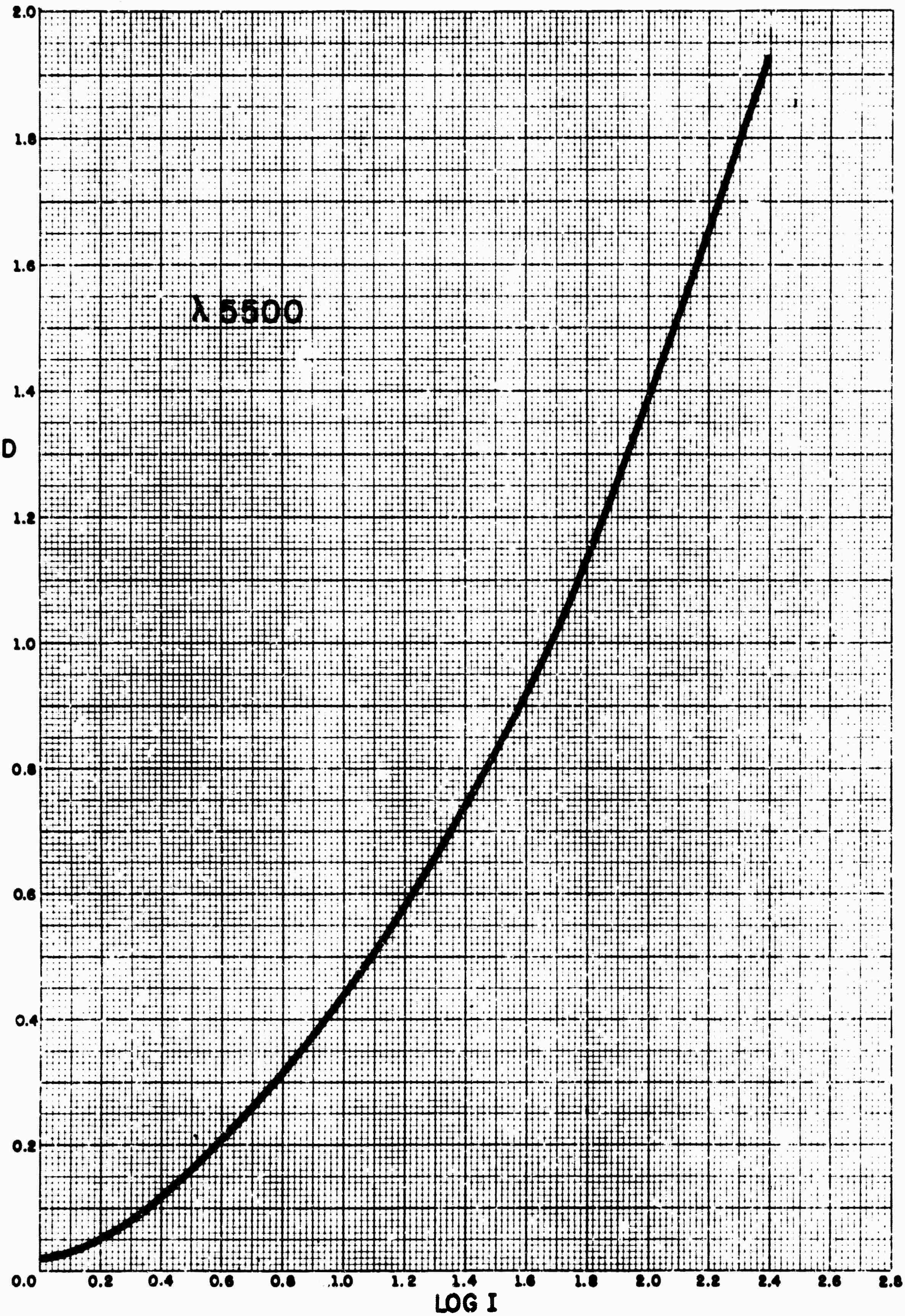

λ 4900 - B
D
LOG I
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8

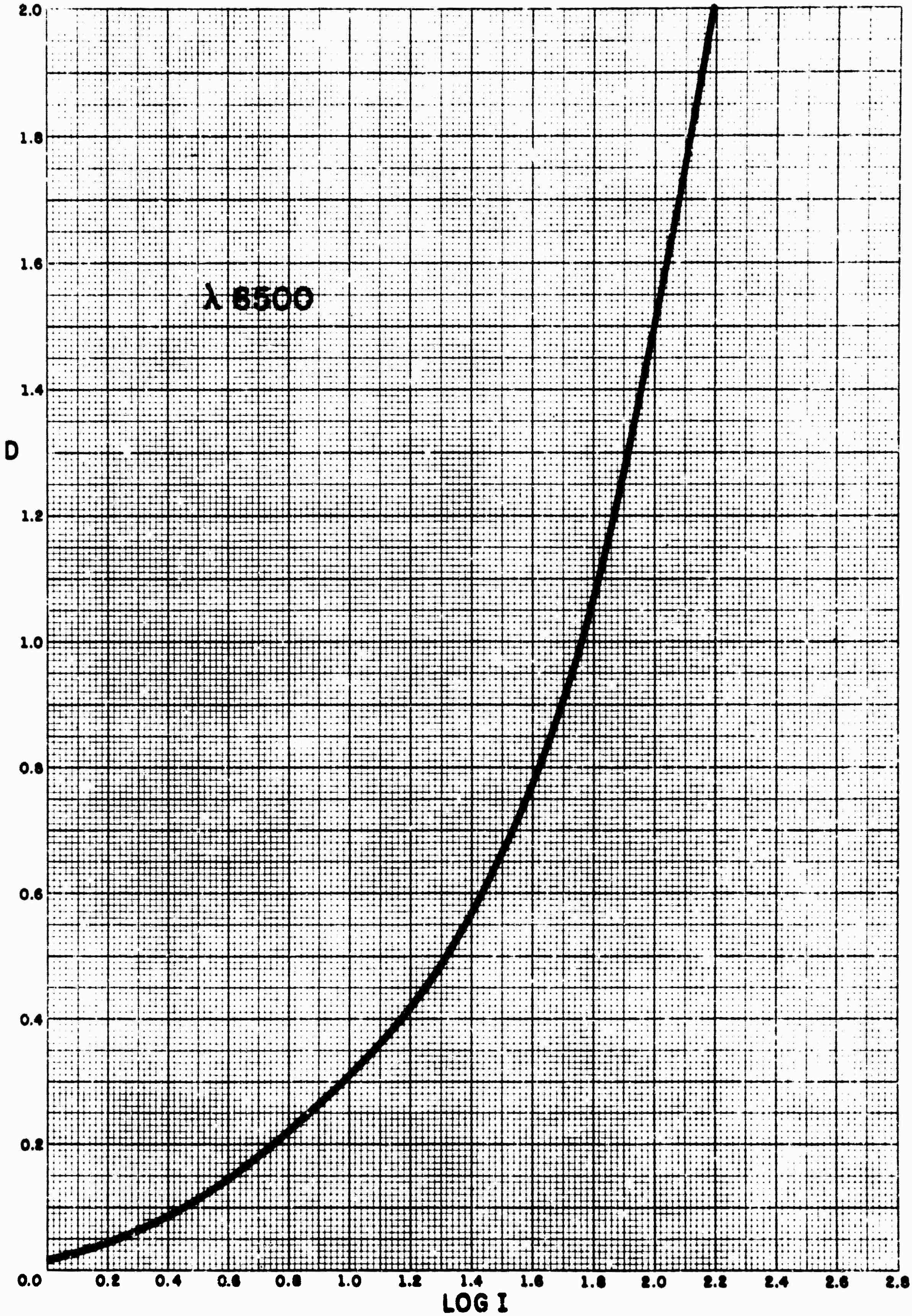

λ 5100
D
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
LOG I


λ 5300
D
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
LOG I

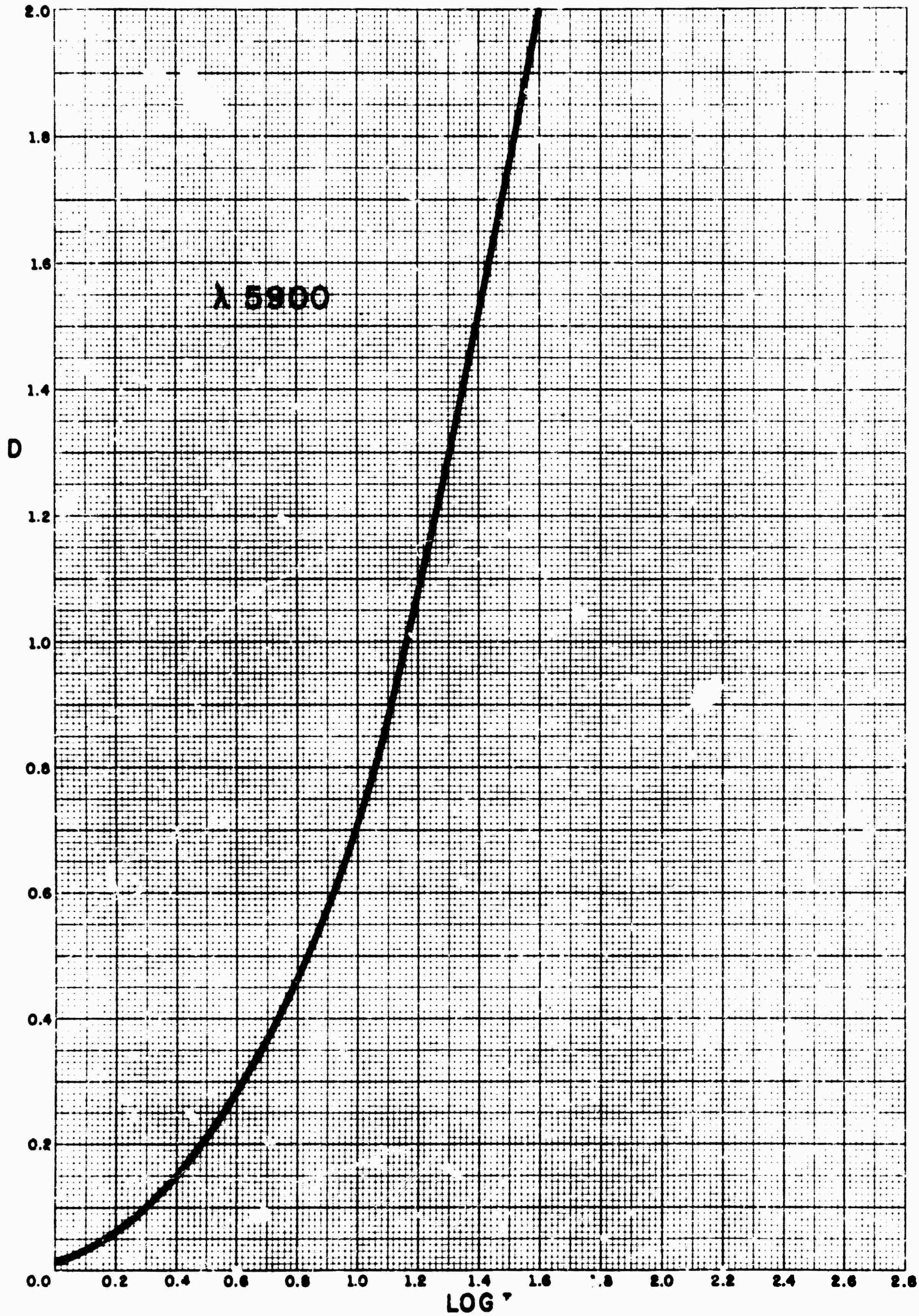

λ 5800
D
LOG I
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8


2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
D
λ 5700
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
LOG I

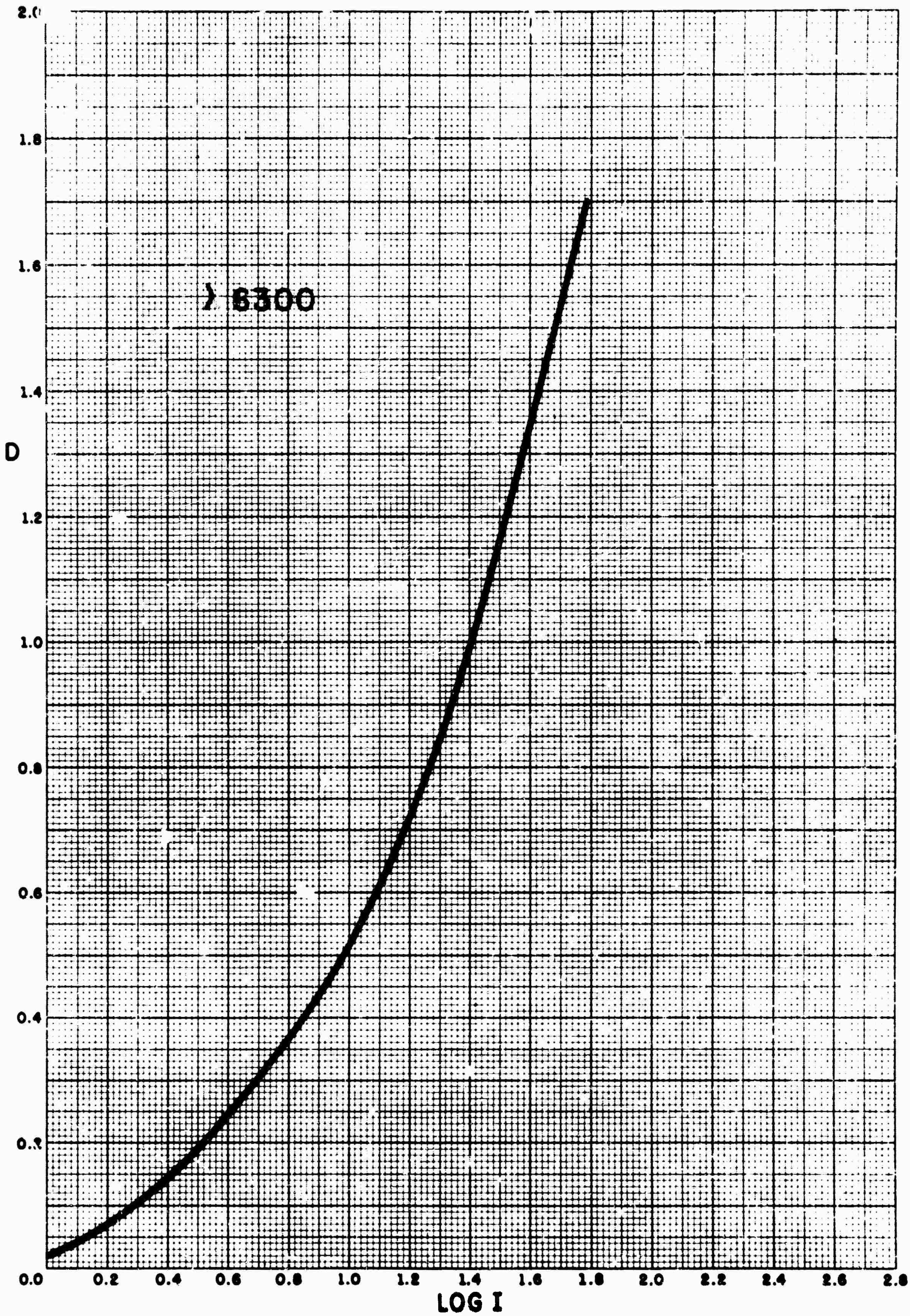

λ 5500
D
LOG I
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8



λ 6500
D
LOG I
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8



D
λ 5900
LOG
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8



λ 6300
D
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
LOG I

12-182

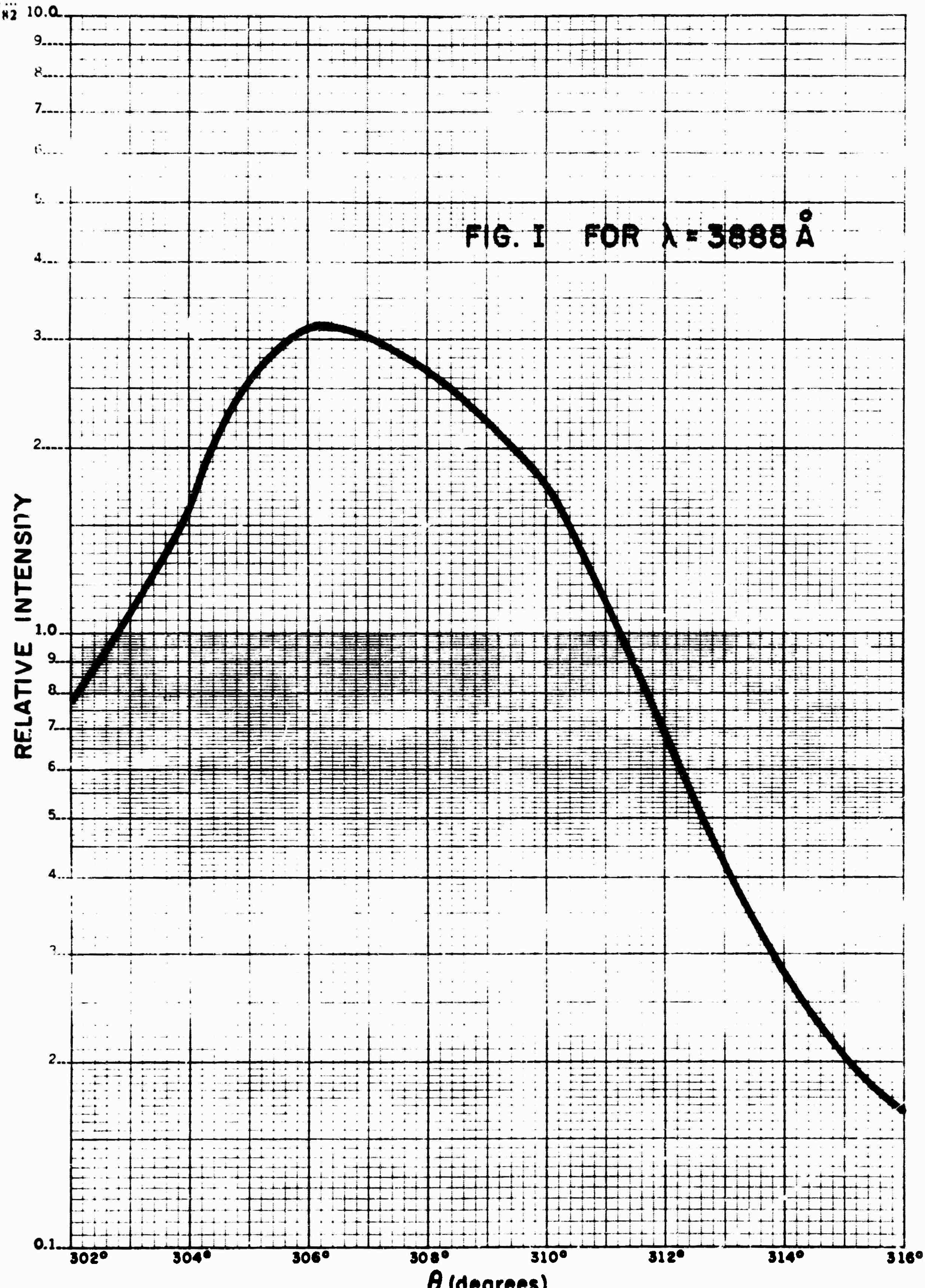


FIG. I FOR λ = 3888 Å

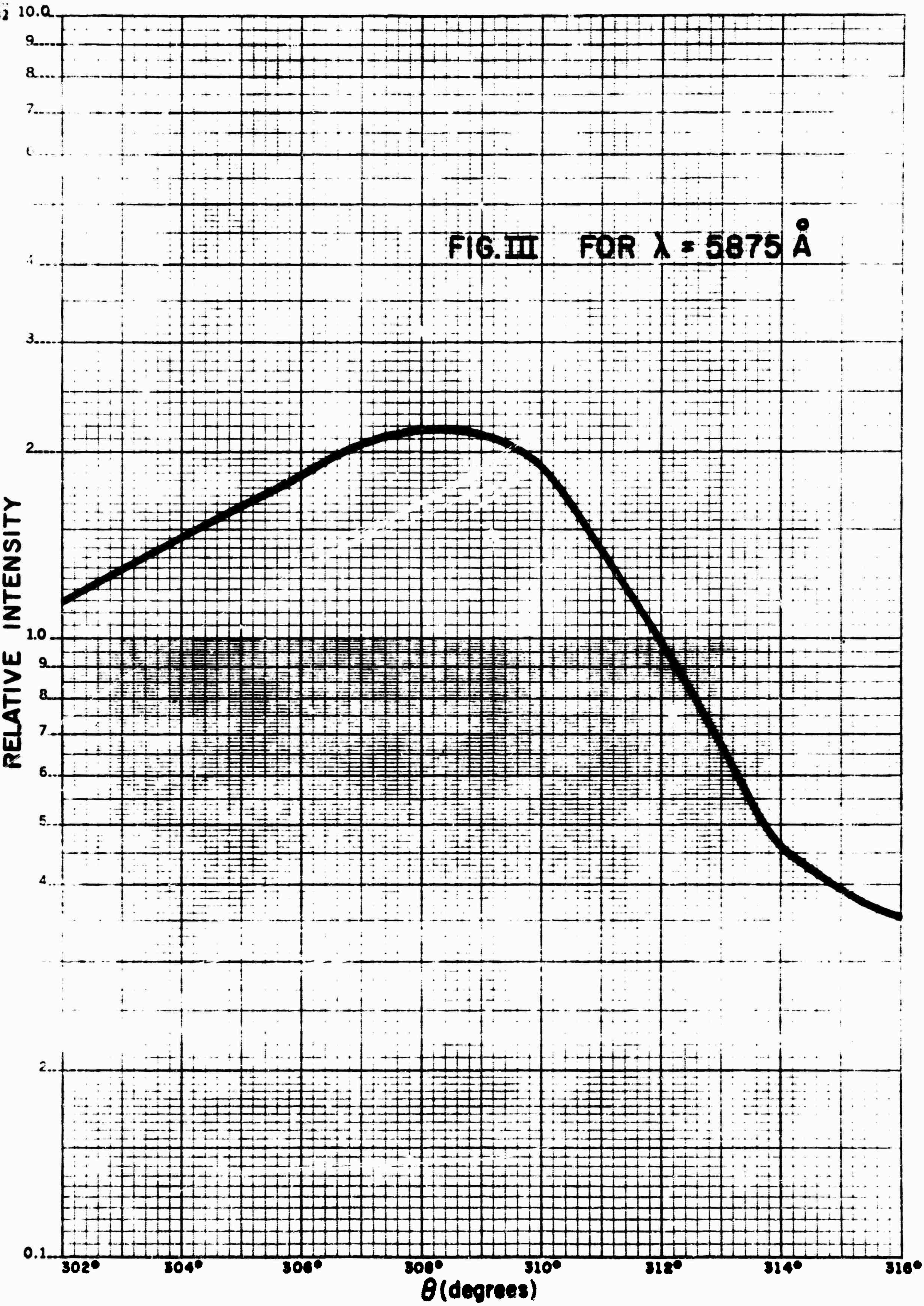


FIG. III FOR λ = 5875 Å
RELATIVE INTENSITY
10.0
9
8
7
6
4
3
2
1.0
9
8
7
6
5
4
2
0.1
302°
304°
306°
308°
310°
312°
314°
316°
θ (degrees)

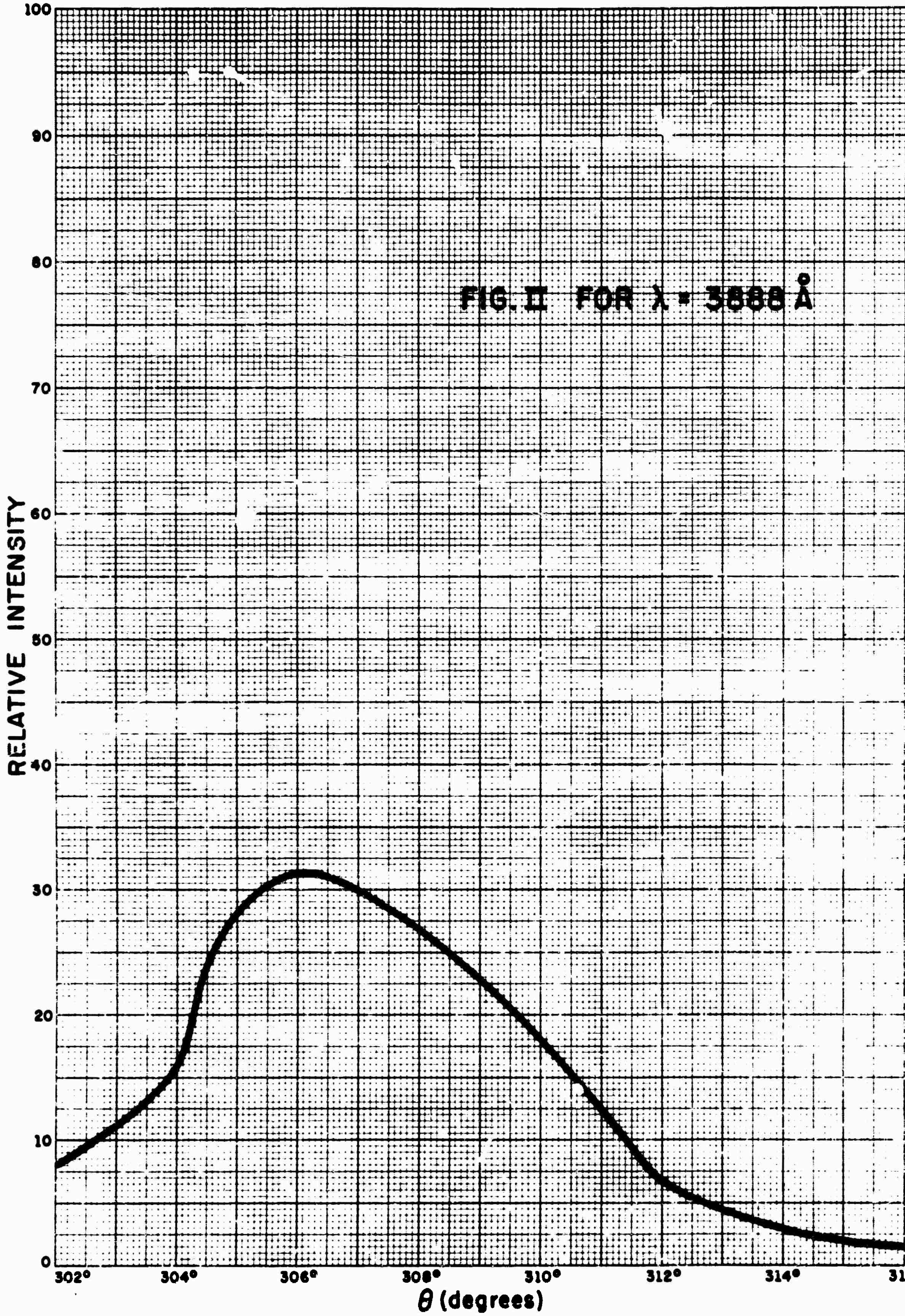


FIG. II FOR λ = 3888 Å
RELATIVE INTENSITY
100
90
80
70
60
50
40
30
20
10
0
302°
304°
306°
308°
310°
312°
314°
316°
θ (degrees)

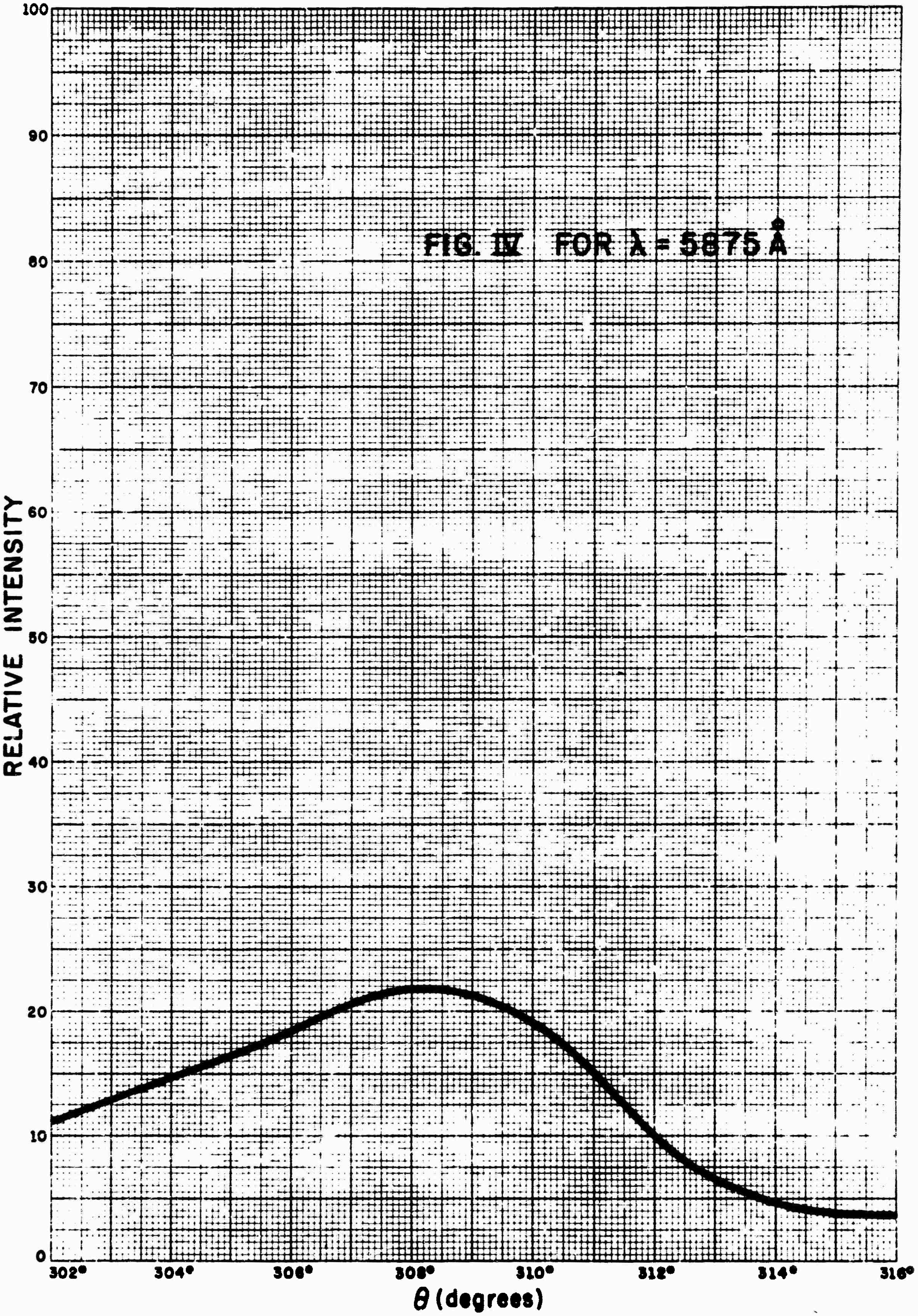
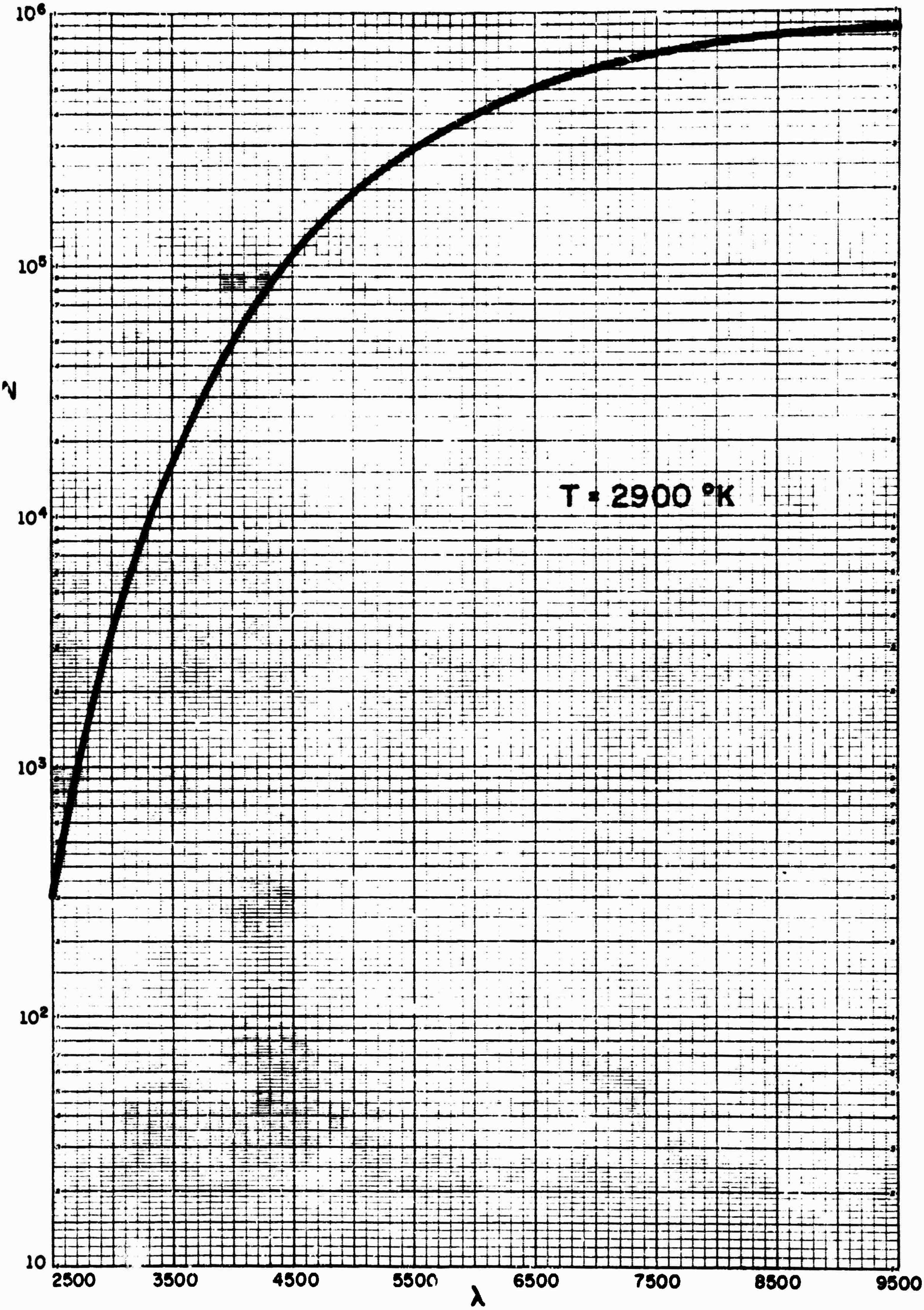


FIG. IV FOR λ = 5875 Å
RELATIVE INTENSITY
0
10
20
30
40
50
60
70
80
90
100
302°
304°
306°
308°
310°
312°
314°
316°
θ (degrees)


T = 2900 °K
N
λ
10^6
10^5
10^4
10^3
10^2
10
2500
3500
4500
5500
6500
7500
8500
9500